НЕТРАДИЦИОННЫЕ И ВОЗОБНОВЛЯЕМЫЕ ИСТОЧНИКИ ЭНЕРГИИ. НЕУГЛЕРОДНАЯ И МАЛАЯ ЭНЕРГЕТИКА

УДК 532.5

ЭКСПЕРИМЕНТАЛЬНОЕ ИССЛЕДОВАНИЕ ХАРАКТЕРИСТИК ПОТОКА ПРИ ОБТЕКАНИИ СФЕРЫ МЕТОДОМ PIV

EXPERIMENTAL INVESTIGATION OF HYDRODYNAMICS FLOW CHARACTERISTICS AROUND A SPHERE USING PARTICLE IMAGE VELOCIMETRY (PIV)

Акрам Абед[1,2], Щеклеин С. Е.[2], Никитин А. Д.[2]
Технический университет, Ирак
Уральский федеральный университет, г. Екатеринбург,
akraaam82@yahoo.com

Akram H. Abed[1,2], Sergey E. Shcheklein[2], Alexandr D. Nikitin[2]
[1]University Of Technology, Iraq
[2]Ural Federal University, Ekaterinburg

Аннотация: Объектом исследования является структура потока при обтекании сферы. Целью работы является экспериментальное определение поля скорости методом PIV и расчёт коэффициента сопротивления потоку. Исследована вихревая структура при обтекании сферы жидкостью в диапазоне числа Рейнольдса Re = 25–200.

Abstract: The vortical structure of a sphere is investigated using a PIV technique at range of Reynolds number Re = 25–200. The main challenges are to understand the flow hydrodynamics and to clarify the flow pattern around a sphere. The purpose of this paper is experimental determination of velocity field and drag coefficient.

Ключевые слова: *сфера; коэффициент сопротивления потоку; поле скоростей; PIV.*

Key words: *sphere; drag coefficient; velocity field; PIV.*

Introduction. Many studies have been conducted to investigate the flow field around a bluff body in a uniform flow. Sphere is considered as an idealized model of three dimensional axisymmetric bluff bodies. On the basis of previous research off low past a sphere, Sakamoto and Haniu [1] visualized the temporal evolution of vortical structure at range of Reynolds number Re = 300–420 with a dye method. Experimental investigation and flow visualization, Bakic and Peric [2], and Bakic et al. [3], shows that the far wake region continues to grow in size and produces a wave like motion. The relation between the Reynolds number and the drag coefficient Cd of a sphere have the sub critical, the critical and the super critical region. In the sub critical region, the drag coefficient shows constant value. In the critical region, the drag coefficient decreases suddenly and reaches a minimum value. In the super critical region, the drag coefficient gradually increases after suddenly decrease [4].

Experimental Setup and Measurements. For this research purpose an experimental Test-Rig was designed and constructed to implement closed forced circulation water flow (Fig. 1).

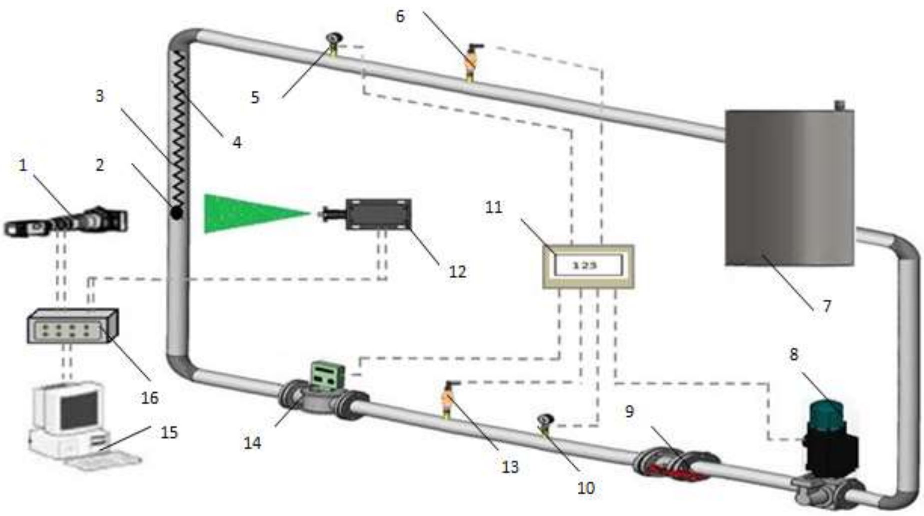

Fig. 1. Schematic diagram of the experimental test-Rig and the PIV method
1 – high speed video camera, 2 – spher, 3 – analyzed element-spring suspension, 4 – clear channel; 5, 10 – temperature sensors; 6, 13 – pressure sensors, 7 – collecting tank, 8 – circulating pump, 9 – stop valve, 11 – block collect information, 12 – laser, 14 – flow meter, 15 – computer, 16 – block synchronization

It comprises the following components: flow circuit, measurement devices, laser (pulsed), CCD camera, seeding arrangement for PIV measurements, and data acquisition system. Velocity measurements around a sphere have been carried out in the water tunnel, using Particle Image Velocimetry (PIV).Which made it possible to measure the spatial distributions of two and three components of the instantaneous flow velocity, to calculate the spatial derivatives of the velocity, and to calculate a whole set of mixed statistical moments. The diameter of the active portion of the test cell (test section) is 50 mm with an overall length of 1m and diameter of the sphere is 24 mm. The pilot scheme of the stand is shown in Fig. 2.

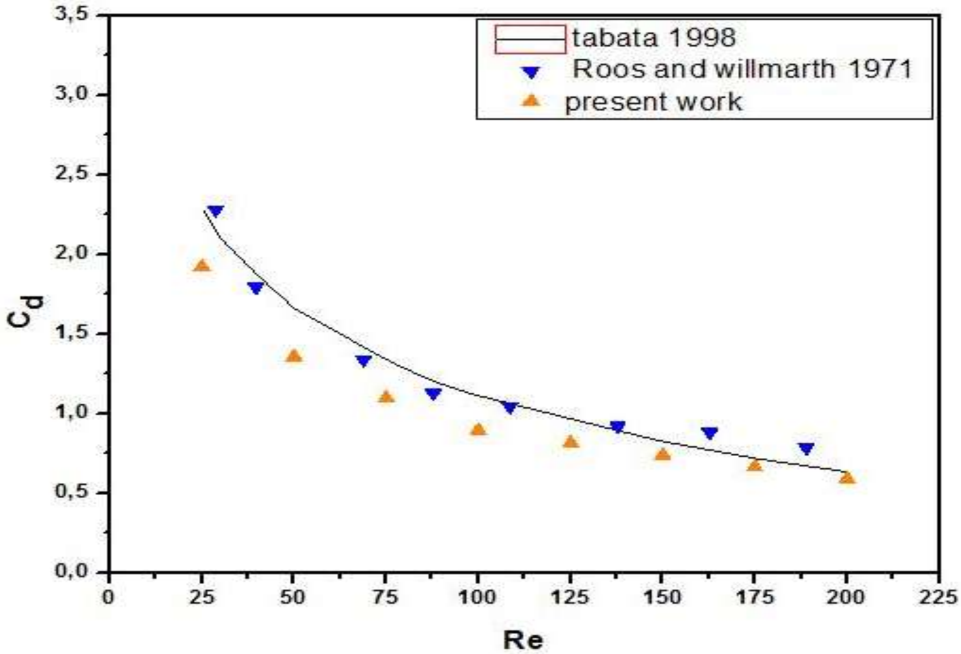

Fig. 2. Relationship between drag coefficient and Reynolds number

Figure 3 shows typical instantaneous velocity fields measured consecutively in the streamwise center plane. We can see the temporal evolution of vortex structure in the near-wake region. Vortices are shed alternatively in the upper and lower regions, and they go downstream with wavy fluctuations. The vortical structure in this streamwise center plane shows typical unsteady and asymmetric flow pattern, comprising of alternatively shedding vortices. The relation between the Reynolds number and the drag coefficient shown in Fig. 3.

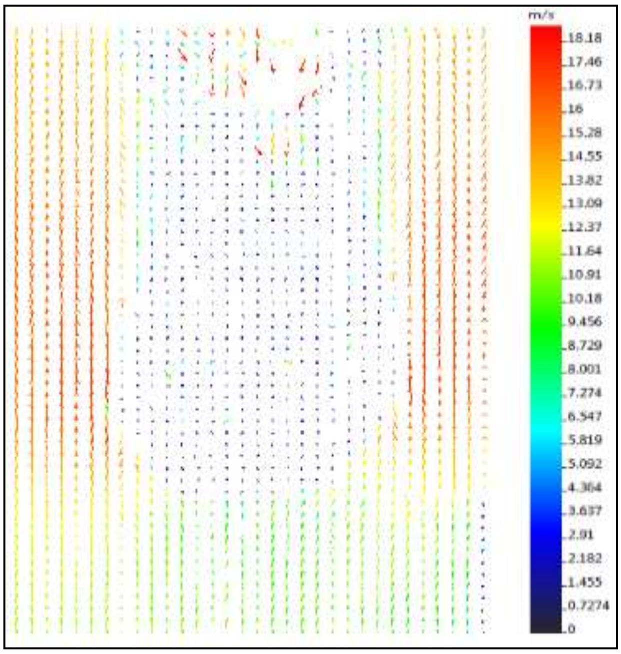

Fig. 3. Velocity vectors and streamlines

Conclusions:

1. Developed experimental bench and measurement methods enable you to receive information on stationary and non-stationary characteristics of hydrodynamic flows around bodies of complex shapes.

2. The results of the verification experiments showed fairly good convergence of the results obtained with the data of other authors.

References

1. Sakamoto H., Haniu H. A study on vortex shedding from spheres in a uniform flow // J Fluids Eng. – 1990. Iss. 112. – P. 386–392.
2. Bakic V., Peric. M. Visualization of flow around sphere for Reynolds numbers between 22000 and 400000 // Thermo-physics and Aeromechanics. – 2005. – Vol. 12. Iss. 3. – P. 307–315.
3. Bakic V., Schmid, M., Stankovic, B. Experimental investigation of turbulent structures of flow around a sphere // Thermal Science – 2006. – Vol. 10. Iss. 2. – P. 97–112.
4. Clift R., Grace J. R., Weber, M. E. Bubbles. Drops and Particles – New York : Academic Press, 1978. 394 p.
5. Scarano F. Overwiew of PIV in supersonic flows. Particle Image Velocimetry / Ed. By A. Schroeder, C. E. Willert. – Berlin : Springer-Verlag, 2008. P. 445–463.
6. Tabata M., Itakura, K. A precise computation of drag coefficients of a sphere // Fluid Dynam. – 1998. Vol. 9. – P. 303.